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# FROM PERCEPTUAL REPRESENTATION TO NUMERICAL MODEL: QUANTIFYING THE INFLUENCE OF SPATIAL INFORMATION CARRIERS IN A NUMERICAL MODEL

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**INTRODUCTION:** A significant limitation in advancing methods for hydrological prediction in ungauged basins has been the problem of parameter identification at catchment scales. Even in areas that have been intensively monitored the collation of appropriate data and its conversion into meaningful, spatially-varying, model parameters is a non-trivial task. Two approaches that have shown promise for improving this situation are the utilisation of tracer data and spatial classifications of catchment characteristics. The objective of this study was to translate a perceptual representation of runoff processes in a meso-scale catchment into a numerical model, using a soil hydrological classification and topographic data to define the spatial variability in processes and tracer data to help support the model parameterisation.

**STUDY AREA:** The study was undertaken in the Girnock catchment, which drains an area of 27km$^2$ in the Cairngorm Mountains of NE Scotland (Figure 1). A perceptual representation of the catchment processes has been developed from a combination of field observations and spatial datasets of topography, soils, geology and land use (Figure 2). Data collection in the catchment included a range of hydochemical and isotopic variables at a range of scales and these have assisted in identification of the primary flow paths and estimation of residence times for a number of sub-catchments (Tetzlaff et al., 2007).

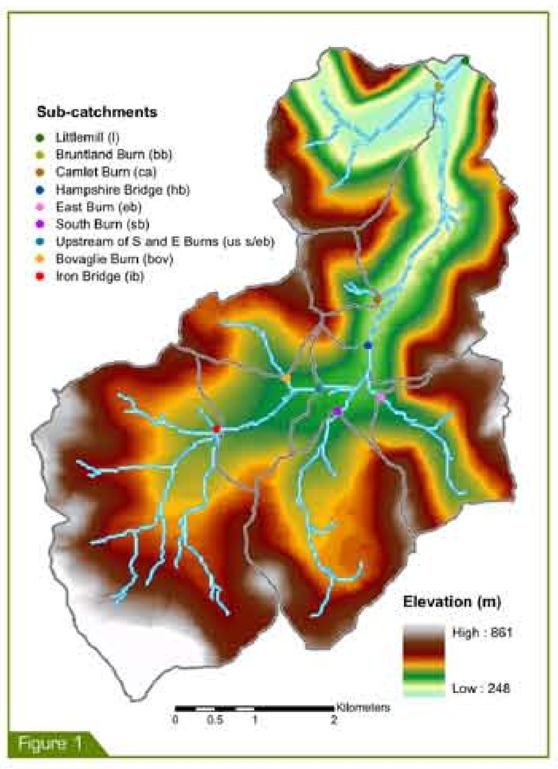

Figure1: Map of Girnock catchment, showing elevation, streams, sampling sites and sub-catchment boundaries

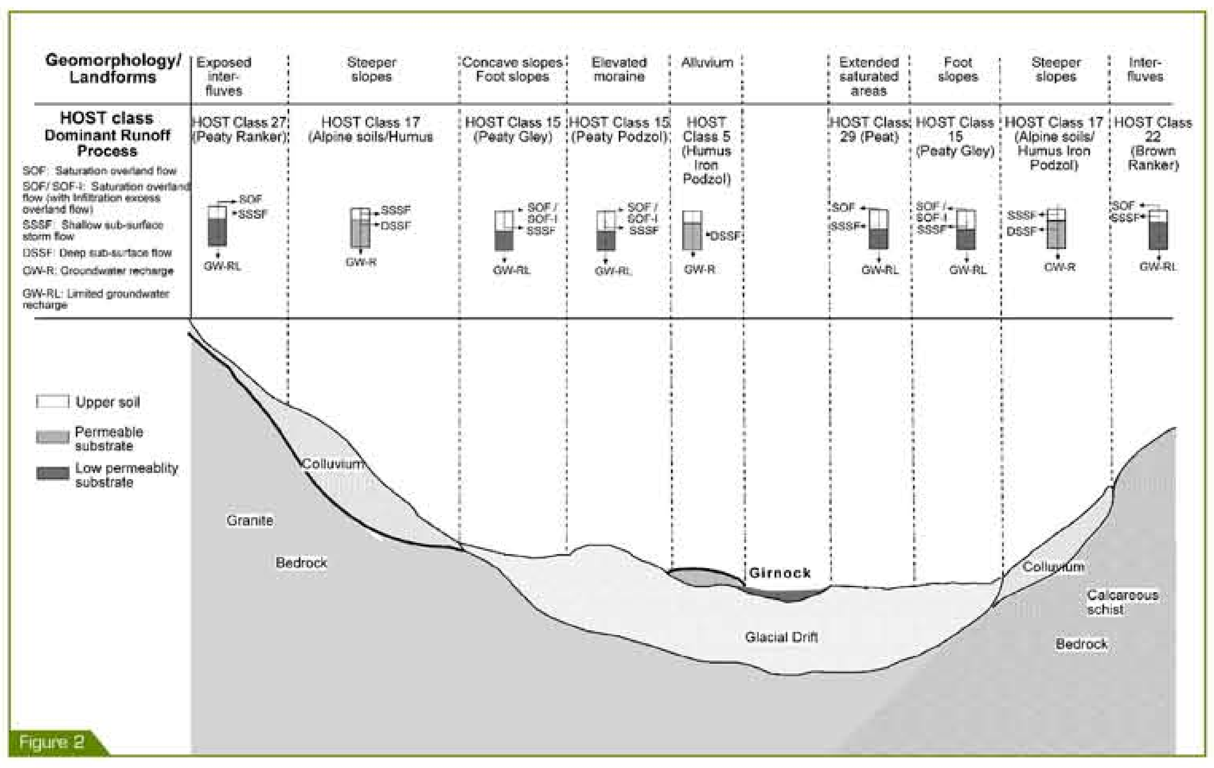

Figure 2: Perceptual model of dominant hydrological processes in the Girnock catchment

**MODELLING APPROACH:** The STorage REsidence times And Mixing (STREAM) model was used as the tool to translate the perceptual representation of processes into numerical reality. The STREAM model is a conceptual semi-distributed hydrological model that can be used to model tracer fluxes in addition to stream flows, and hence allows for the application of multi-criteria calibration using tracer data as well as stream flows. In common with the perceptual representation of the catchment, the Hydrology Of Soil Types (HOST) classification was used to represent the spatial variability in soils within the catchment (Figure 3). A key objective of the model calibration procedure was to identify parameters for the HOST classification that generated model predictions consistent with the perceptual representation of processes, yet at the same time giving acceptable goodness of fit parameters for prediction of stream flows and tracer fluxes.

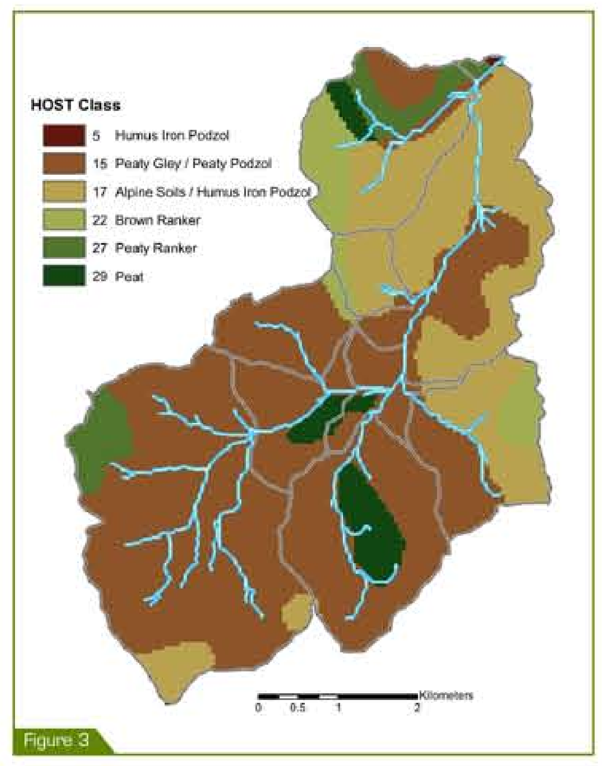

Figure 3: Distribution of HOST classes in the Girnock

**RESULTS:** Multiple simulations were run using the model to identify acceptable parameter sets using the following sequence of simulations:

1) 6 individual soil types were applied homogenously to catchment area. Simulated proportion of near surface runoff and groundwater flow were used to select pairs of values for two soil transport parameters, *calibV* and *calibL*.

2) The top 10 parameter sets for each soil type were randomly combined with each other to generate a heterogeneous model of soils in the catchment. The best combinations of soil parameters were selected on the basis of stream flow predictions.

3) Homogeneous values for other model parameters were identified through further calibration, and linked with the best combinations of soil parameters.

The best simulations from 3) in terms of Nash Sutcliffe efficiency were deemed to form the *pareto* parameter sets for the model. Figure 4 shows an envelope of the simulated stream signal of $\delta^{18}O$ compared with observed data for this set of simulations.

In order to assess the success of the heterogeneous soil parameters, simulations of $\delta^{18}O$ and alkalinity were examined at a sub-catchment scale. This analysis demonstrated that the simulations of $\delta^{18}O$ were relatively insensitive to the spatial heterogeneity in soils at a sub-catchment scale (Figure 5). This is consistent with the observed data. The modelled variability in alkalinity was much greater, but this was clearly driven by the differences in groundwater alkalinity between the sub-catchments (Figure 6). Neither set of simulations provides adequate validation of the spatial heterogeneity in soil parameters.

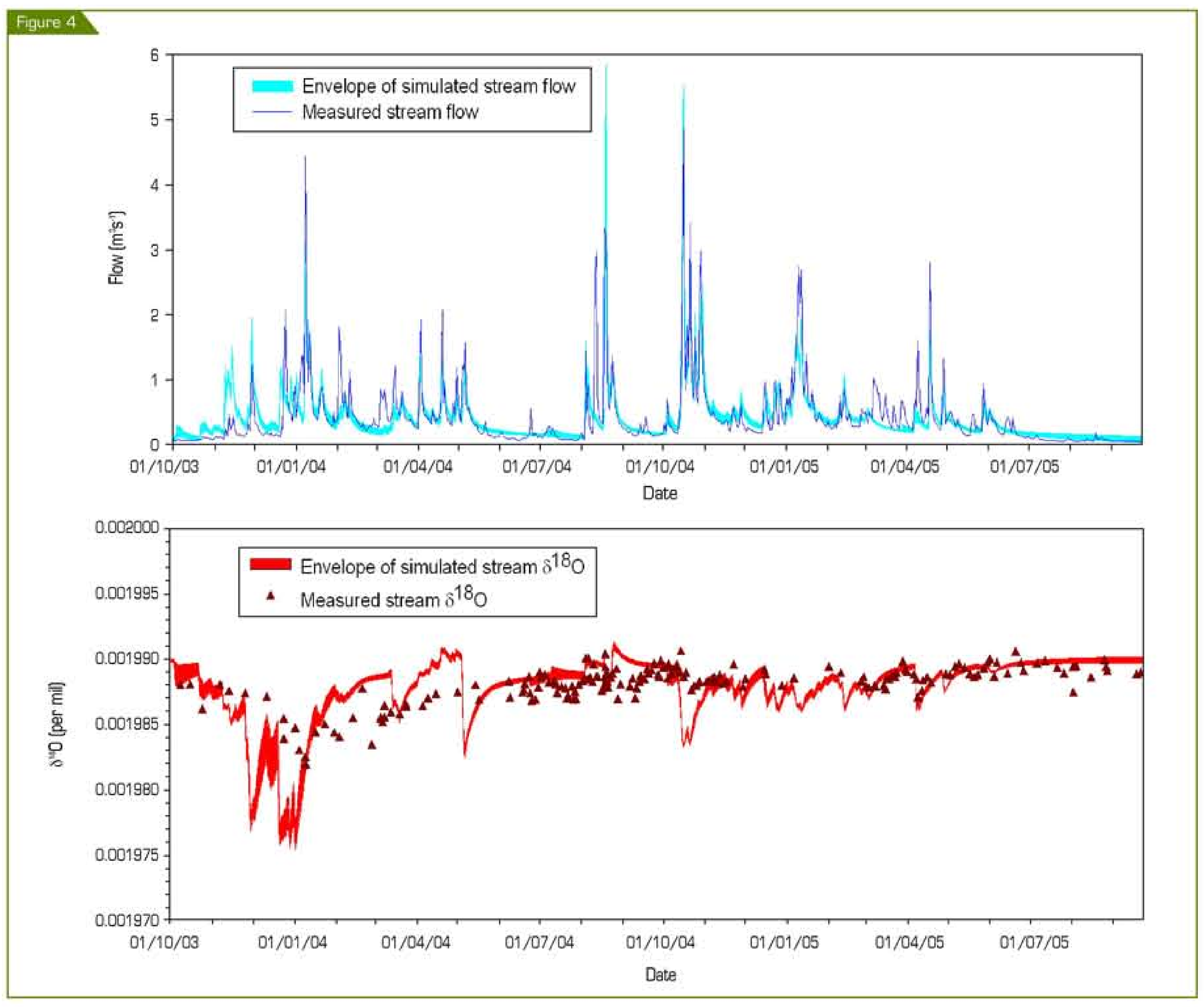


Figure 4: Modelled envelopes of stream flow and $\delta^{18}O$ at catchment outlet for two hydrological years

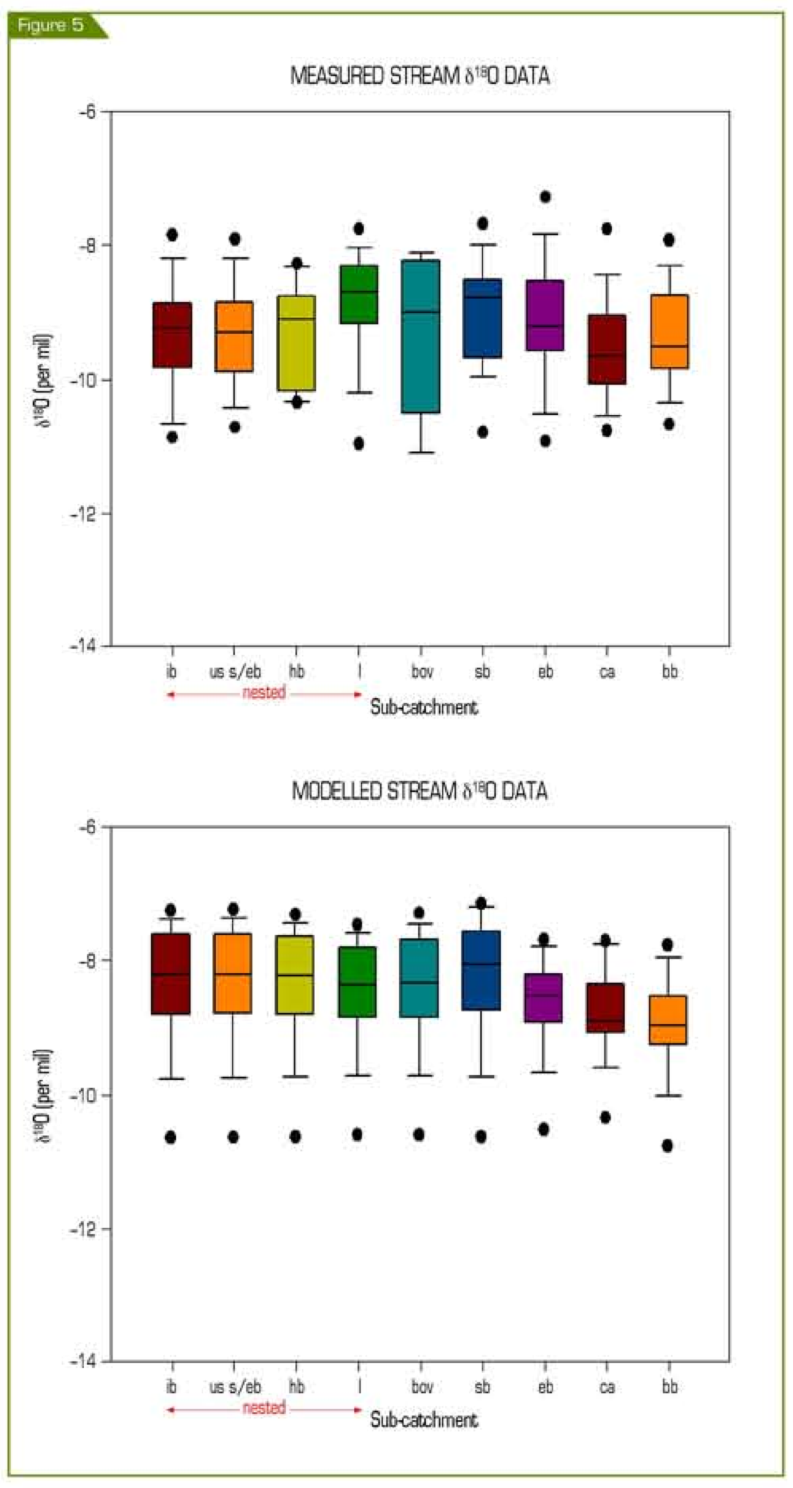


Figure 5: Variability in modelled $\delta^{18}O$ at the sub-catchment scale

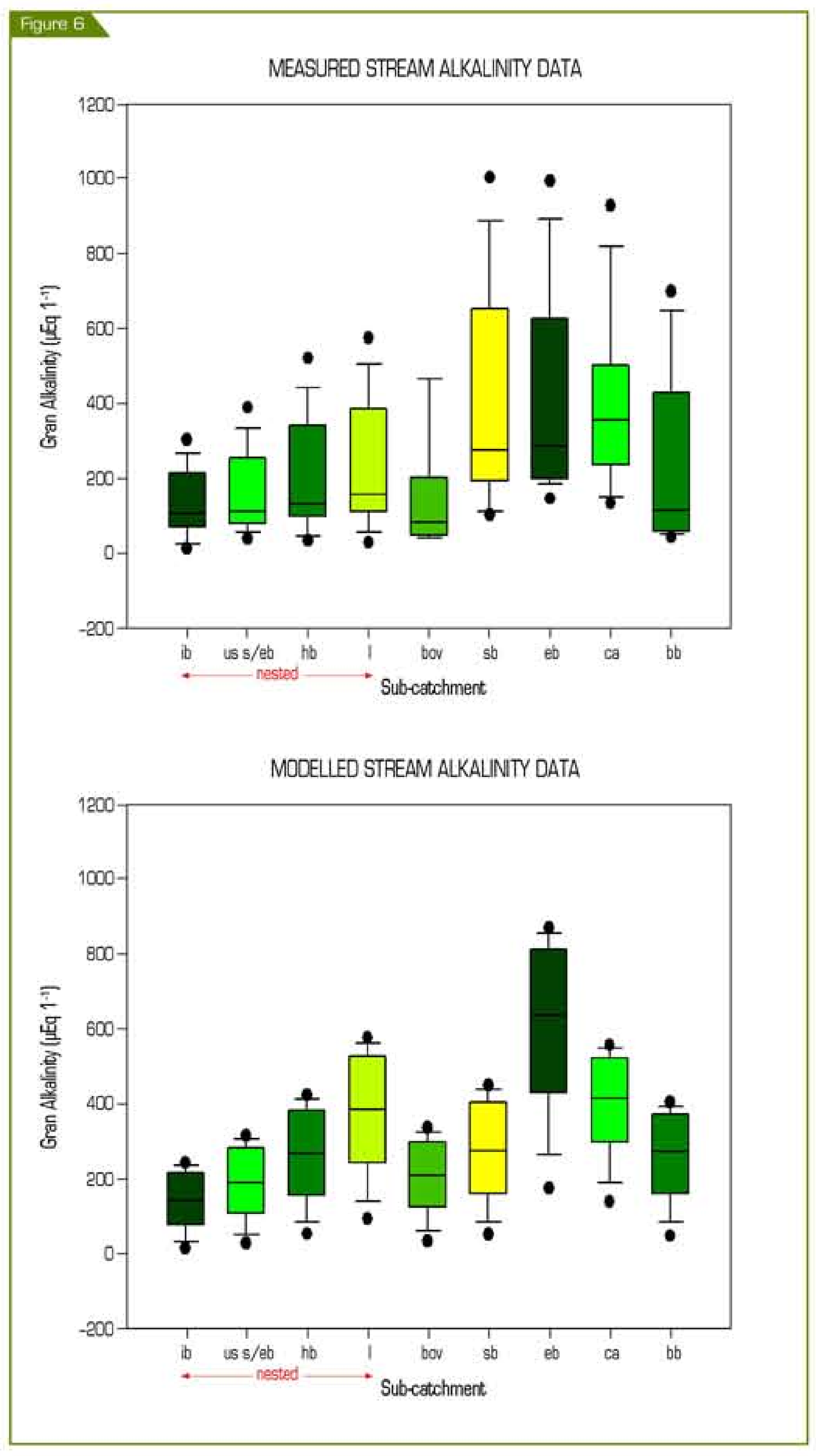


Figure 6: Variability in modelled Gran alkalinity at the sub-catchment scale

**CONCLUSIONS:** A methodology for selecting appropriate spatially-distributed soil parameter sets was successfully applied to the Girnock catchment, but found to be difficult to validate using sub-catchment scale data. This may reflect the fact that all of the sub-catchments are dominated by hydrologically responsive soils, which result in broadly similar rainfall-runoff relationship in $\delta^{18}O$.

**Reference:** Tetzlaff, D. Soulsby, C., Waldron, S., Malcolm, I. A., Bacon, P.J., Dunn, S., Lilly, A., and Youngson, A. F. Conceptualisation of runoff processes using tracers and GIS analysis in a nested mesoscale catchment. 2007. Hydrological Processes 21: 1289-1307.

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